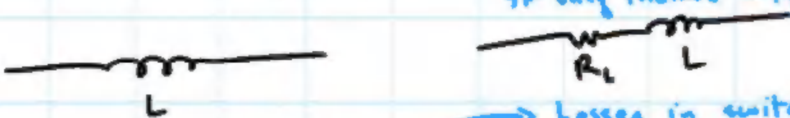
Losses in converters

Thursday, March 18, 2021 9:24 AM

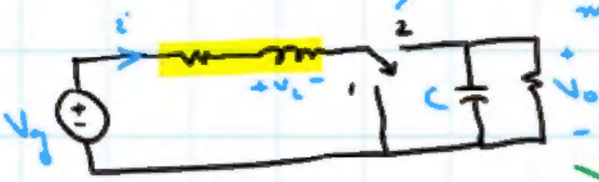
→ There are no ideal elements.

→ Let us model a practical inductor.

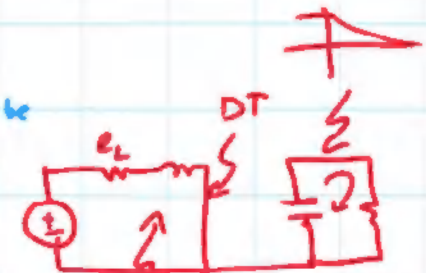
It only include copper loss



Losses in switch will be modeled later on



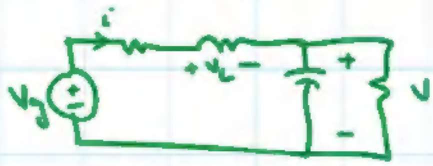
→ D = 1



current flow controlled only by the R_L

$$v_L(t) = V_g - i(t)R_L$$

$$i_c(t) = \frac{-v(t)}{R}$$



$$v_L(t) = V_g - i(t)R_L - v(t)$$

$$i_c(t) = i(t) - \frac{v(t)}{R}$$

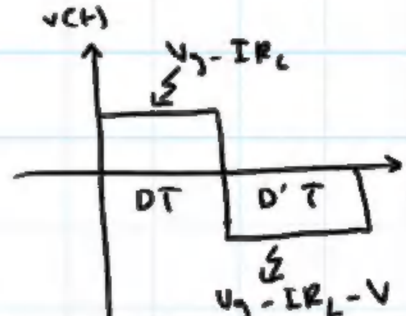
Apply the SRA.

$$v_L(t) = V_g - IR_L$$

$$i_c(t) = \frac{-V}{R}$$

$$v_L(t) = V_g - IR_L - V$$

$$i_c(t) = I - \frac{V}{R}$$



Volt-sec balance through $v_L(t)$ waveform

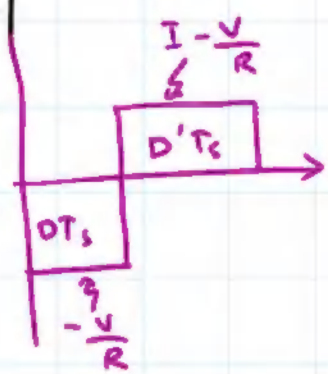
$$\overbrace{\langle v_L(t)\rangle}^{\text{Avg value}} = DT_s(V_g - IR_L) + D'T_s(V_g - IR_L - V) = 0$$

For steady state it is zero

$$\hookrightarrow 0 = \underbrace{V_g}_{i/p} - \underbrace{IR_L}_{\text{unknown.}} - D'\underbrace{V}_{o/p} \quad \text{———} \quad (A)$$

To slove (A) capacitor charge-sec balance is used

$$\langle i_c(t)\rangle = DT_s(-V/R) + D'T_s(I - V/R) = 0$$



$$0 = D'I - V/R \quad \text{———} \quad (B)$$

using (A) & (B)

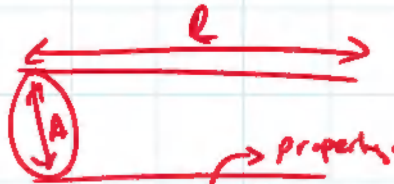
—— (C)

using Ⓐ & Ⓑ

$$m(D) = \frac{V}{V_g} = \frac{1}{D'} \frac{1}{\left[1 + \frac{R_L}{D'^2 R}\right]} \quad \text{— Ⓒ}$$

plot $m(D)$ as a function of D and R_L/R

Eq C
- If $R_L = 0$ then $V/V_g = \frac{1}{D'} = \frac{1}{1-D}$ and it shows ideal Boost converter
- If $R_L << D'^2 R$ then $\frac{V}{V_g} \cong \frac{1}{D'}$
- If $R_L > D'^2 R$ then $\frac{V}{V_g}$ in reduced.
- At $D = 1$ the $m(D)$ tends to zero.



→ property of material.

$$R = \frac{\rho l}{A}$$

A ↑ winding space occupy ↑

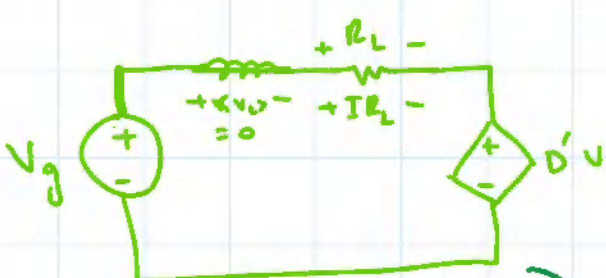
larger core ↑ power density ↓

Let us derive Ⓒ using DC Transformer

we need Ⓐ and Ⓑ

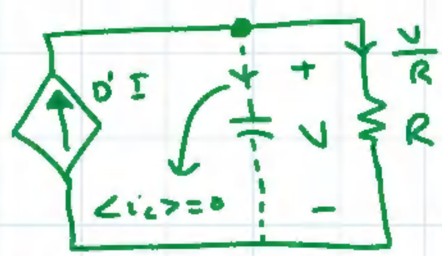
Ⓐ → $V_g - IR_L - D'V = 0 = \langle v_L \rangle$

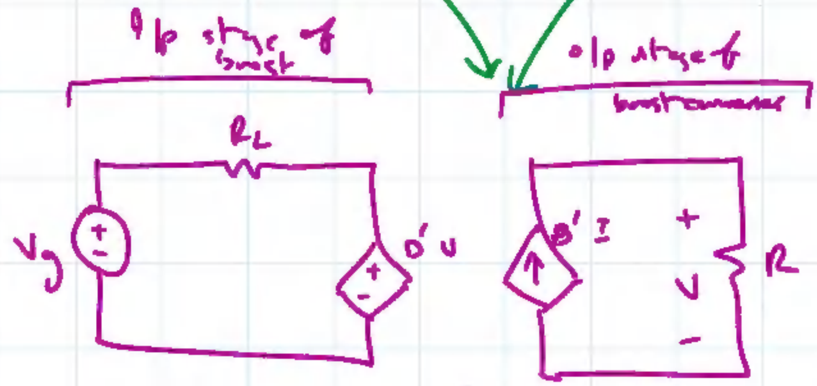
- V_g: i/p voltage → independent voltage source
- IR_L: voltage drop → modeled using R_L
- D': controlling parameter; V: o/p voltage → modeled as a dependent source.



Ⓑ → $D'I - \frac{V}{R} = 0 = \langle i_c \rangle$

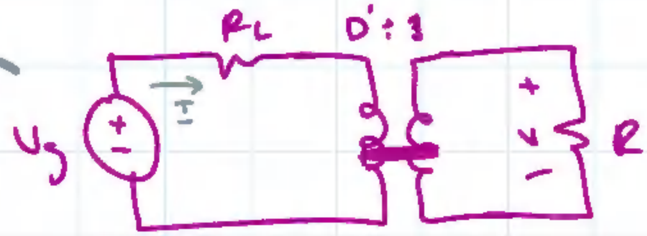
- D': controlled variable; I: current → Dependent source
- $\frac{V}{R}$ → R
- $\langle i_c \rangle$ → capacitor current = 0
- V → o/p voltage





$1 : n(D)$

$n(D) : 1$



$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$D' : 1 = \frac{V_p}{V_s}$$

$$V_s = \frac{V_p}{D'}$$

$\eta = ?$

$P_{in} = V_g I$

$P_o = V D' I$

$$\eta = \frac{V D' I}{V_g I}$$

$$= \frac{V}{V_g} D'$$

putting value of V

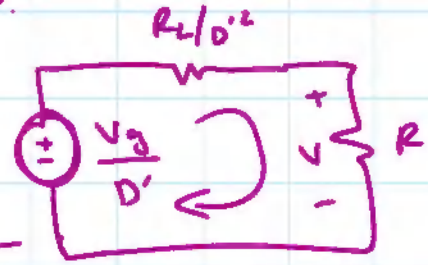
$$\eta = \frac{1}{1 + \frac{R_L}{D'^2 R}}$$

Matlab plotting (E)

Transfer primary side to the sec side.

$$V_g \xrightarrow{\text{sec}} \frac{V_g}{D'}$$

$$R_L \xrightarrow{\text{sec}} R_L / D'^2$$



$$\left.V = \frac{V_g}{D'}\left(\frac{R}{R + \frac{R_L}{D'^2}}\right)\right\} \text{VDR}$$

$$\boxed{\frac{V}{V_g} = \frac{1}{D'} \frac{1}{1 + \frac{R_L}{D'^2 R}}} \quad \text{—— (D)}$$

Eq (C) and (D) are same.

plot eq (C) & (E) in matlab with addition to different ratios of $\frac{R_L}{R}$ given in the book